An Overview of ExPRESS, WORF, and MSG Platforms

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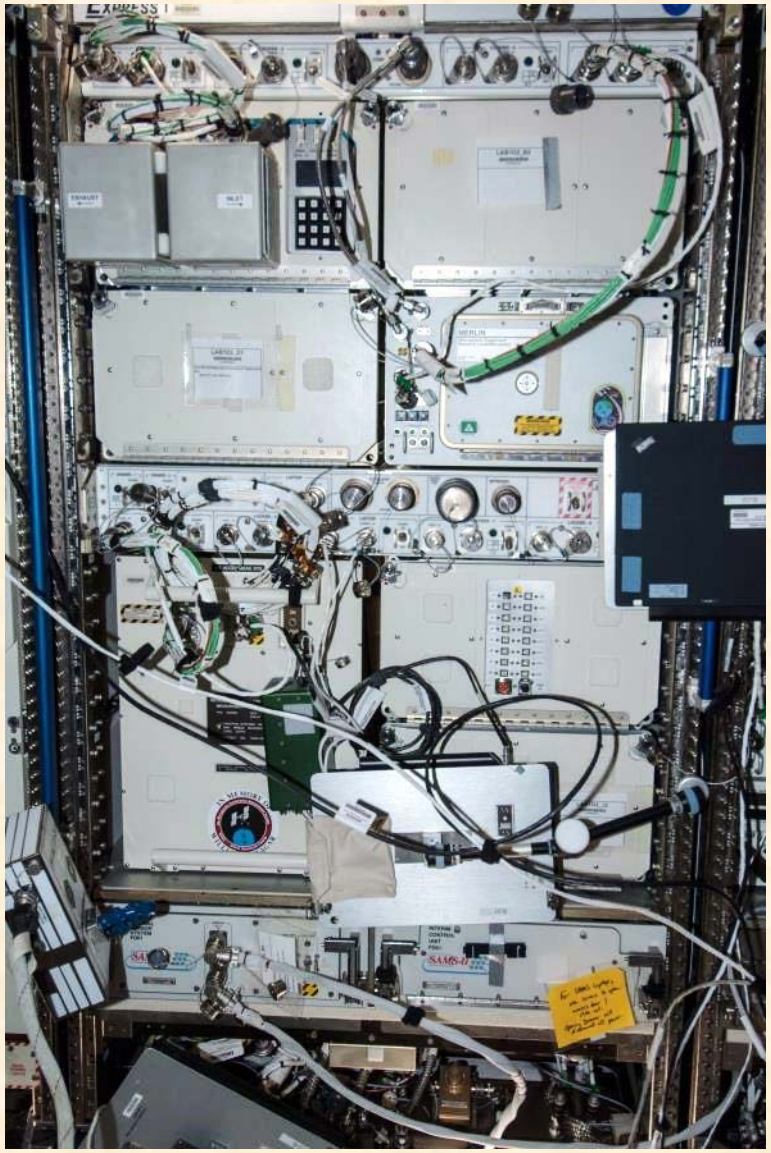
Outline

- **Payload Rack Facilities**
  - **Expedite the Processing of Experiments to Space Station (EXPRESS) Overview**
  - **Window Obserervational Research Facility (WORF) Overview**
  - **Microgravity Science Glovebox (MSG) Overview**

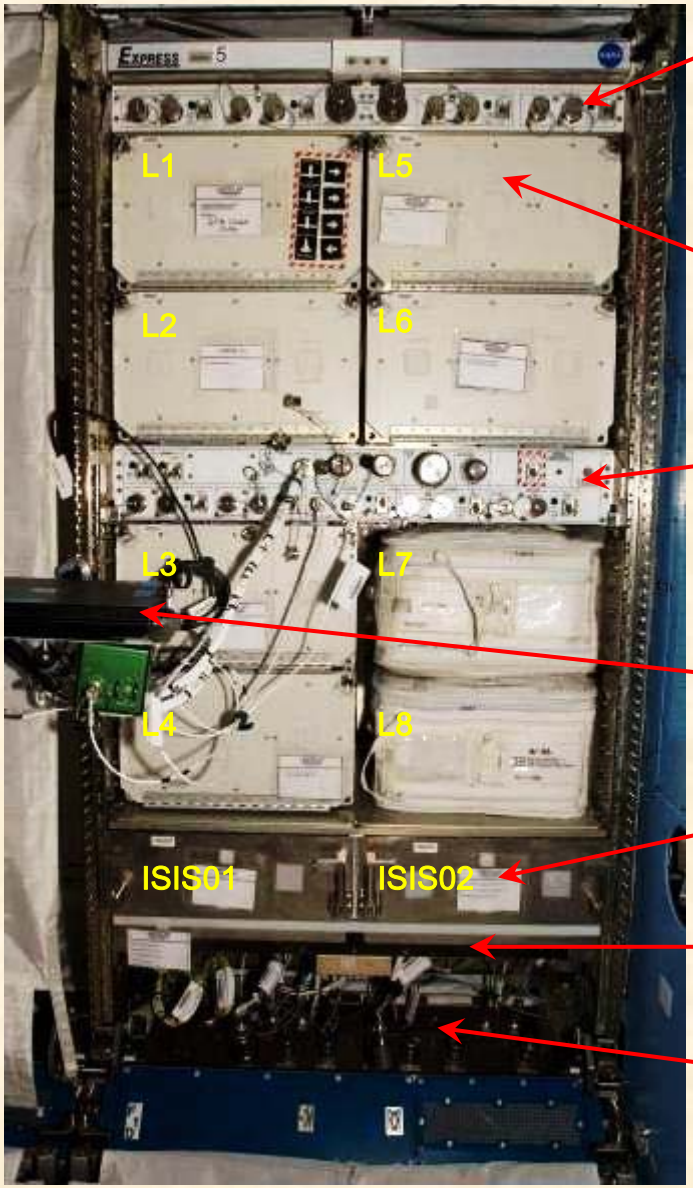
EXPRESS Rack

- **EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack** is a multi-use facility which provides standard interfaces and resources for 8 locker-type and 2 drawer-type payloads
- **Payload Interfaces**
  - Power: 28 Vdc
  - Data: Ethernet, RS-422, Analog, Discrete
  - Video: NTSC
  - Cooling: Air (all locations) and Water (2 locations per rack)
  - Vacuum Exhaust (1 location per rack)
  - Nitrogen Supply (1 location per rack)



EXPRESS Rack 1, 7/9/13

EXPRESS Rack Front View



Upper Connector Panel

Lockers (8 locations)

Lower Connector Panel

EXPRESS Laptop Computer (ELC)

ISIS Drawers (2)

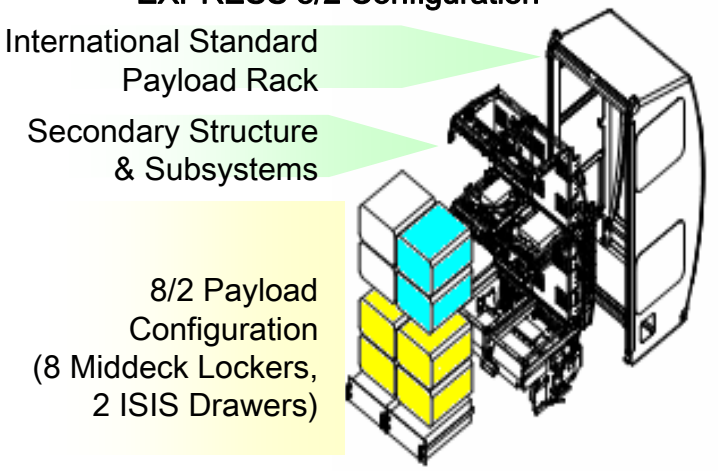
Utility Drawer

Utility Interface Panel

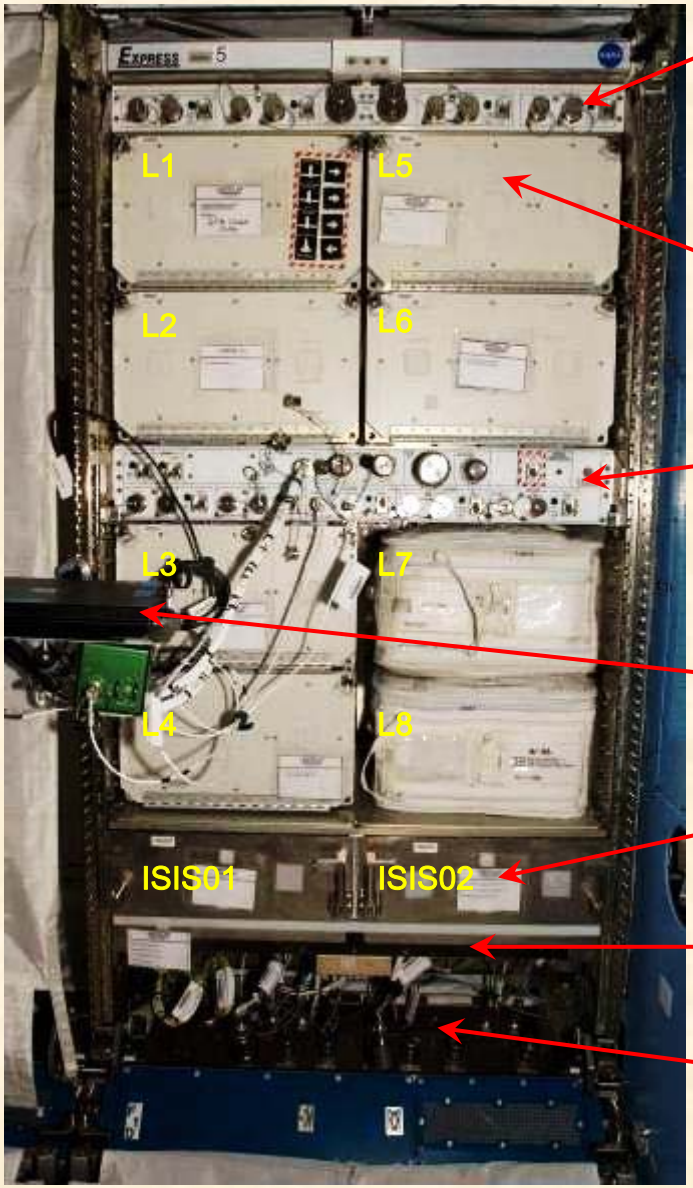
Payload configuration options:

- **Insert into a NASA-provided ISS Locker**
- **Integrate into an International Subrack Interface Standard (ISIS) Drawer**
- **Design single unit to replace 1, 2, or 4 lockers.**

EXPRESS 8/2 Configuration



EXPRESS Rack Front View



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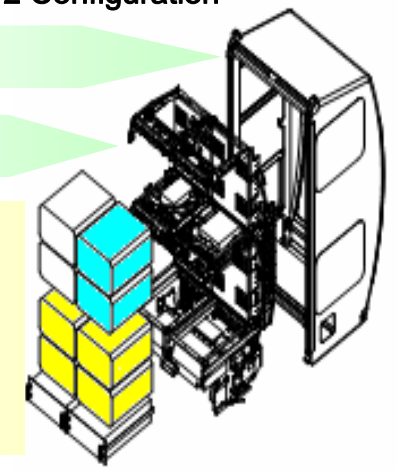
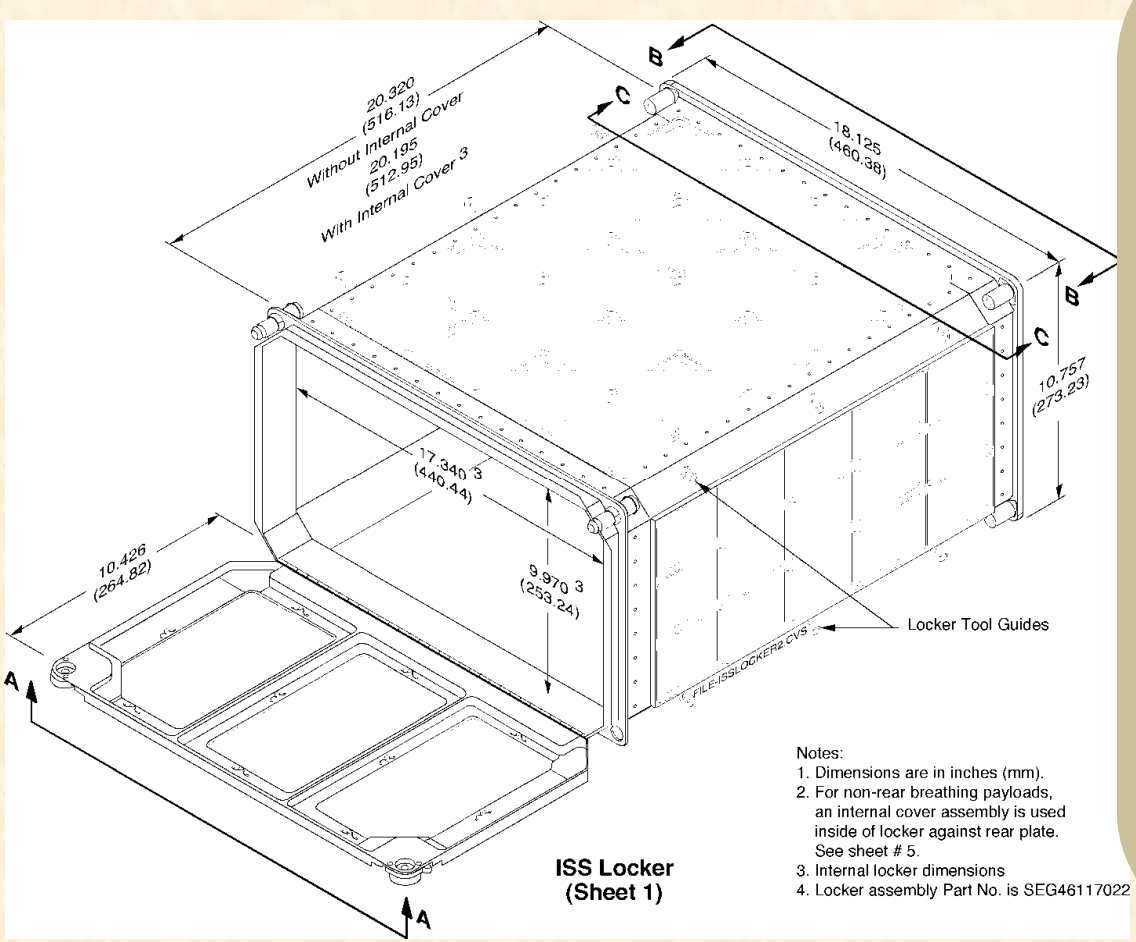


EXPRESS ISS Locker Details



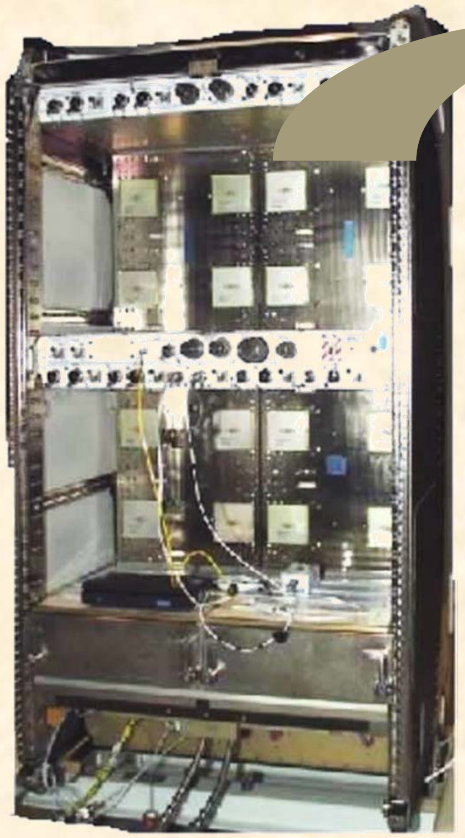
Features

- 4 rear captive fastener attachments
- Installation tool guides on 4 corners
- Friction hinge
- Dual door locks
- 3 removable panels on door
- Rear internal closeout removed for active payloads
- Internal dimensions (ref)
  - Width 17.340 in.
  - Height 9.970 in.
  - Depth 20.320 in.
- Weight – 13 lbs. empty
- Internal Volume – 2 ft^3

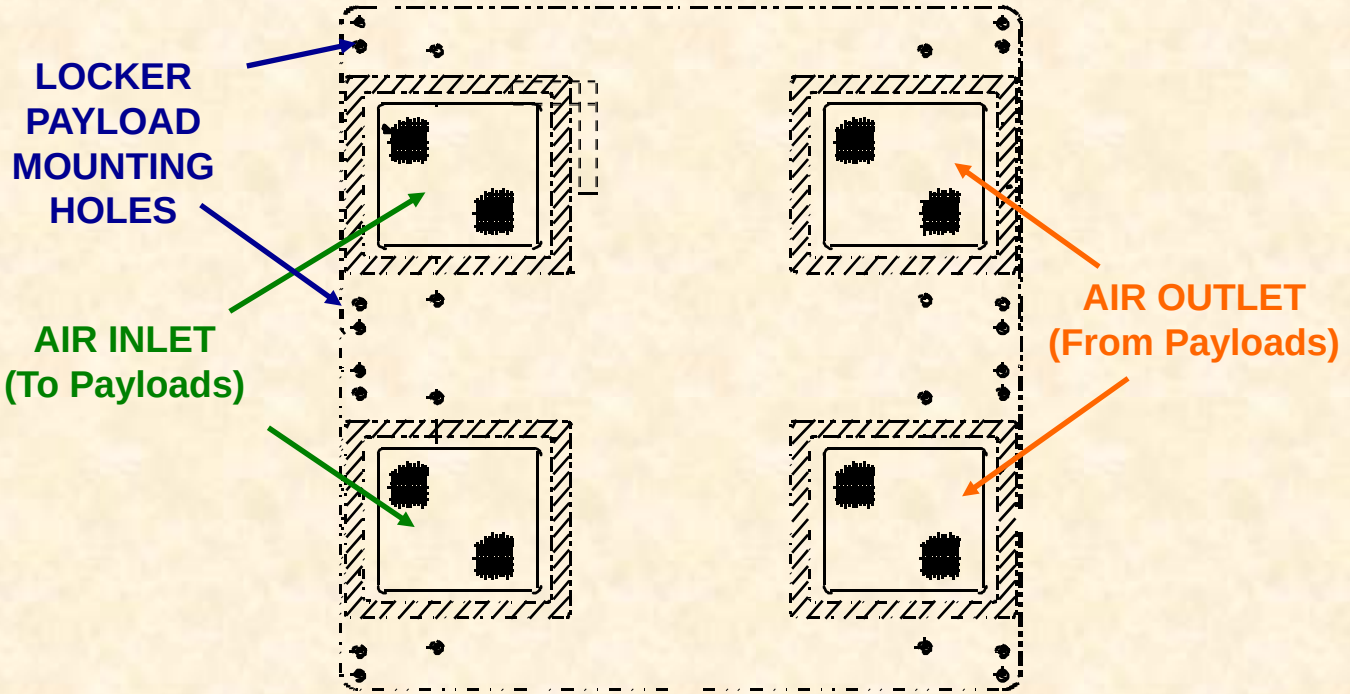
Payloads can either be locker “inserts” or locker “replacements”

EXPRESS Subrack Payload Mounting

- Mounting for 8 single ISS lockers (or equivalent) and 2 ISIS drawers
- Subsystem equipment located behind connector panels or mounting plates



Front View

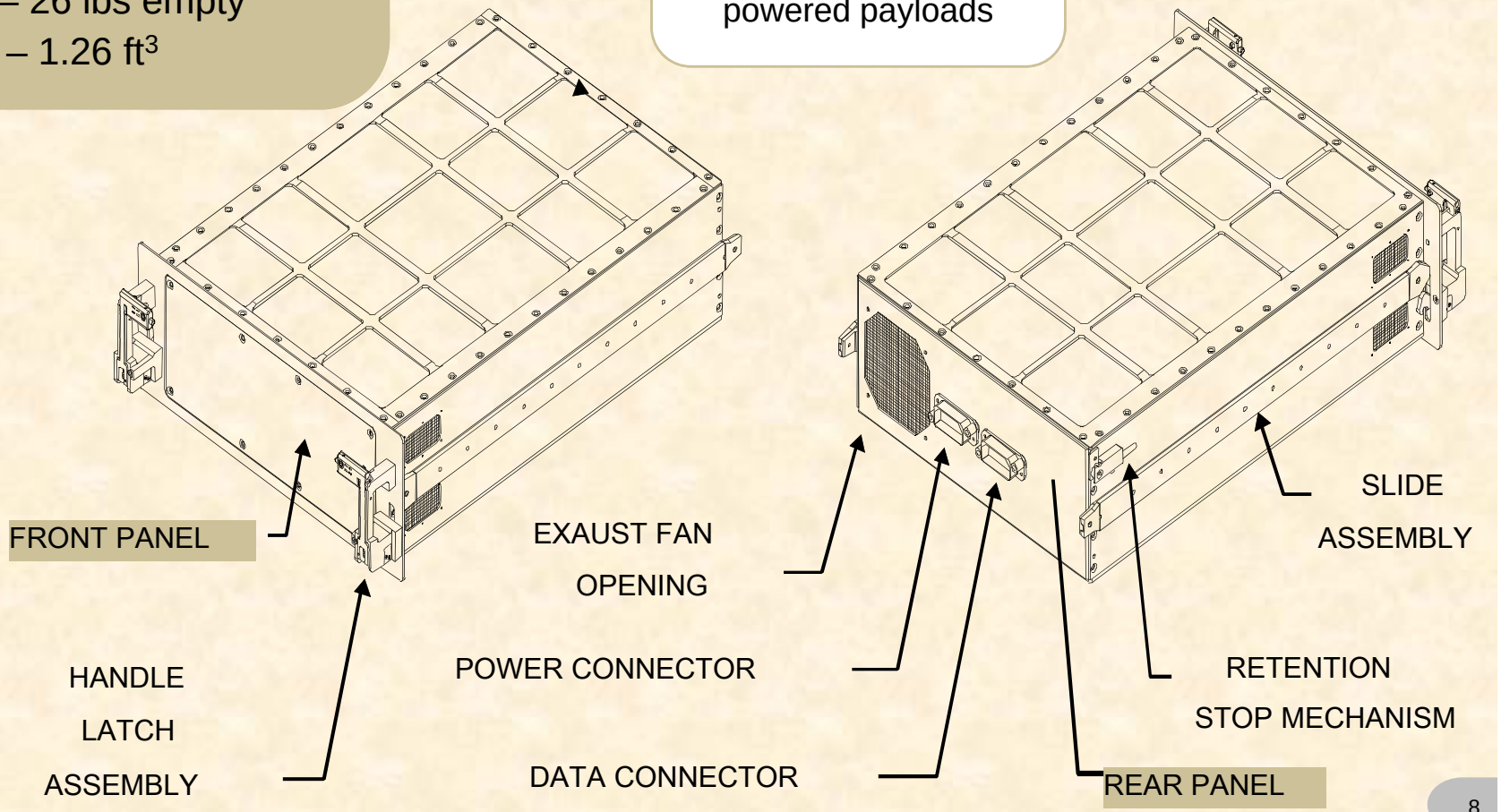


EXPRESS Powered ISIS Drawer

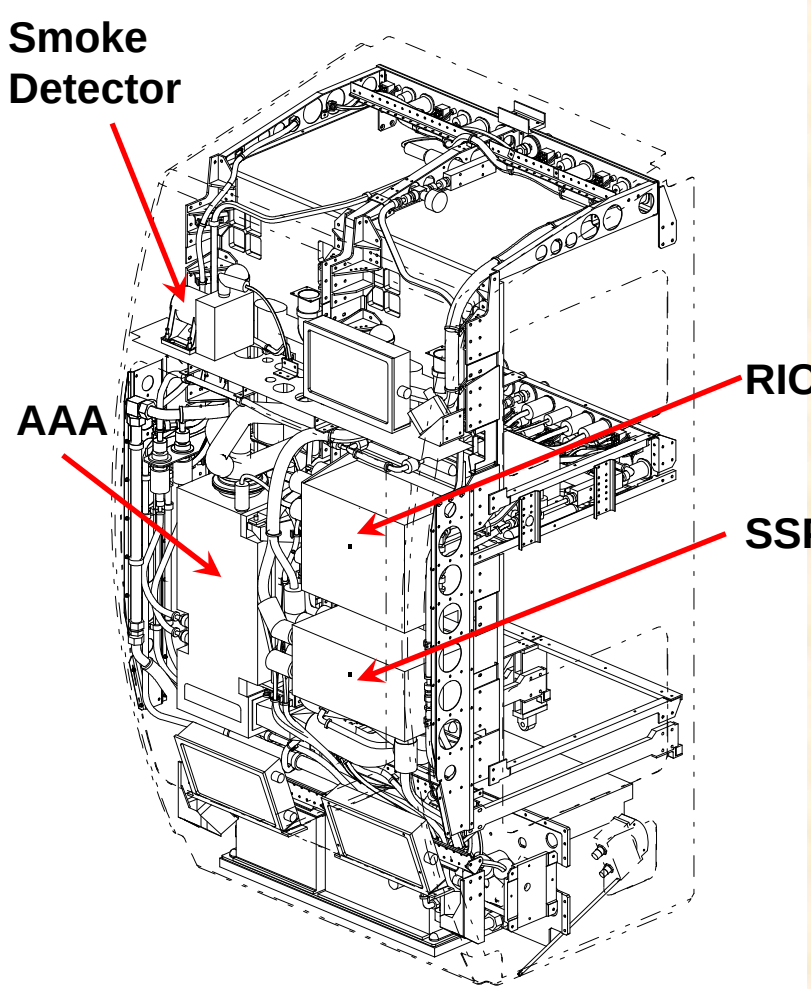
Features

- Blind-mate connectors
- Locking handles
- Internal dimensions (ref)
  - 15.94 x 5.88 x 23.23 in.
- Weight – 26 lbs empty
- Volume – 1.26 ft^3

NASA provides a powered ISIS drawer for ground integration of powered payloads



EXPRESS Subsystems

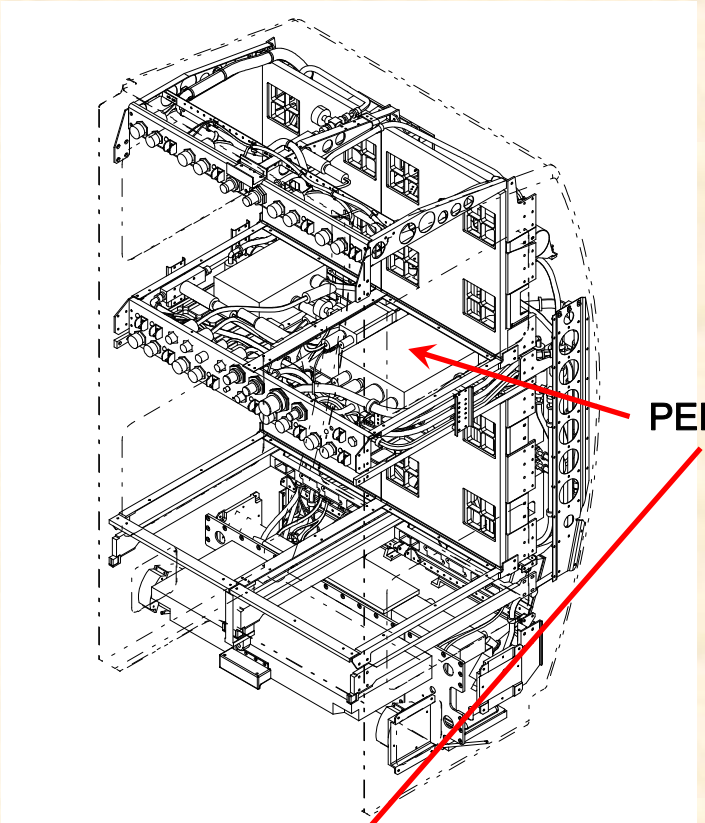


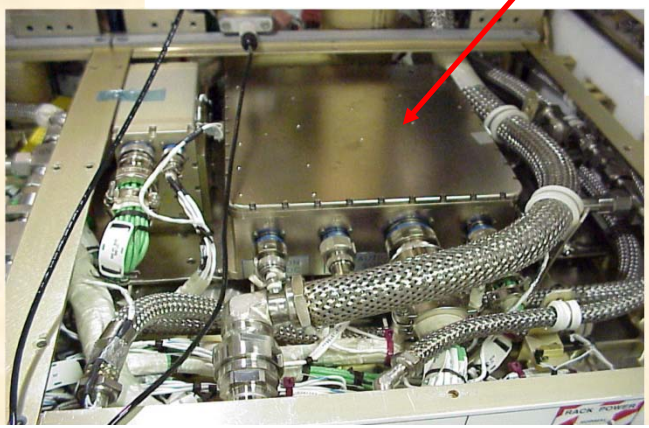
Rear View

- **RIC: Rack Interface Controller**
  - Provides command and control of rack subsystems and payloads and interfaces with the ISS Payload MDM.
  - Collects health and status from rack subsystems and payloads.
- **SSPCM: Solid State Power Control Module**
  - Receives ISS main power and provides power to rack subsystems and payloads.
  - Provides discrete and analog I/O to payloads and rack subsystems.
- **AAA: Avionics Air Assembly**
  - Provides air cooling to payloads and exchanges heat with the Moderate Temperature Loop.
  - Circulates air for smoke detection

EXPRESS Subsystems

- **PEHB: Payload Ethernet Hub Bridge**
  - Provides primary means of communication between EXPRESS rack, the payloads, and the ISS.
  - Provides 10 Mbps Ethernet data packet transfer between payloads, laptops, and the RIC and provides a bridge to the ISS LANs for telemetry downlink.
  - Command and data interface to EXPRESS laptop.
- **PEHG: Payload Ethernet Hub Gateway**
  - Will replace PEHB in 2015 (est.)
  - 100 Mbps Ethernet





EXPRESS Subsystems

ELC: EXPRESS Laptop Computer

- Dedicated to EXPRESS rack operations
- Crew can view rack displays
- Crew can command rack and payloads
- Payload can have applications installed
- Lenovo T61p
- Windows XP SP2 operating system
  - Upgrade to Windows 7 within 2 years

EXPRESS Subsystems

- **Payload Cooling**
  - **Moderate Temperature Loop (MTL)**
    - MTL circulates water through rack
    - Payloads have MTL cooling access at the upper and lower connector panels
    - 500 W per payload position x 2 positions per rack
  - **AAA** – “Rear Breather” payloads (1200 W total rack)
  - **Cabin Heat Load** – “Front Breather” payloads (very limited)
- **Thermal Shutdown**
  - RIC monitors 2 internal sensors that are configured by the PRO (usually a flow sensor and a temperature sensor)
  - RIC will shut down all active payloads and rack if both sensors are out of limits
- **Fire Detection System (FDS)**
  - Provides fire detection for the rack
  - Payload Rear Breathers
    - ISS/EXPRESS-provided by smoke detector within rack
  - Payload Front Breathers
    - Payload-provided parameter monitoring delivered through health & status data to PL MDM

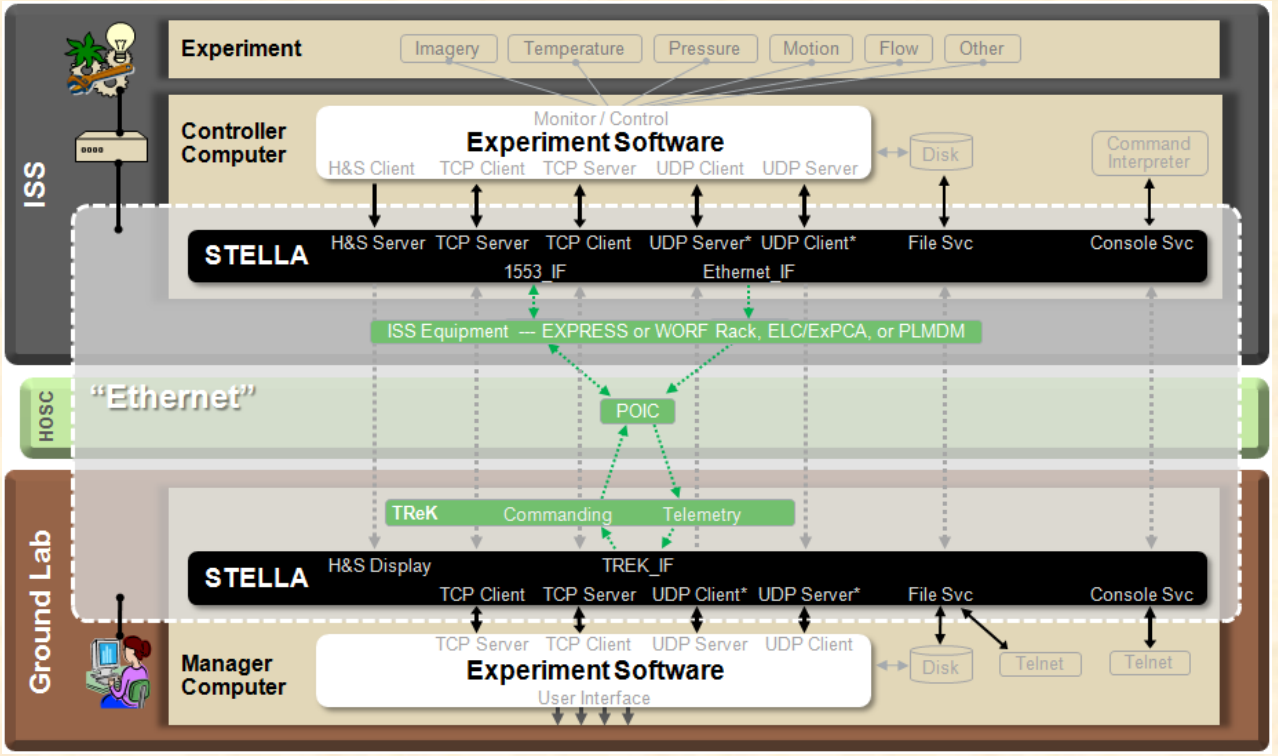
EXPRESS Payload Resources

Resource	Amount per Payload Position	
	Locker	ISIS Drawer
Structural Attachment	Attachment to Rack per IDD •Mass constraint launch vehicle dependent	Attachment to Rack per ISIS Spec •64 lb within cg constraints
Power	5, 10, 15, or 20 Amp at 28 VDC	5, 10, 15, or 20 Amp at 28 VDC
Thermal Control Air	Nominal 150 W (1200 W rack maximum)	Nominal 150 W (1200 W rack maximum)
Thermal Control Water	500 W Heat Rejection per position (2 positions per rack)	500 W Heat Rejection per position (2 positions per rack)
Data	•1 - RS-422 •2 - +/- 5 Vdc Analog •1 - Ethernet •3 - 5 Vdc Discrete (bi-dir)	•1 - RS- 422 •1 - +/- 5 Vdc Analog •1 - Ethernet •2 - 5 Vdc Discrete (bi-dir)
Video	NTSC/RS 170A feed from payload source (Shared)	NTSC/RS 170A feed from payload source (Shared)
Venting	1 payload interface per rack (Shared)	1 payload interface per rack (Shared)
Nitrogen	1 payload interface per rack (Shared, 12 lbm/hr)	1 payload interface per rack (Shared, 12 lbm/hr)

Reference: EXPRESS Rack Payloads Interface Definition Document, SSP 52000-IDD-ERP

Software Toolkit for Ethernet Lab-Like Architecture (STELLA)

- **Developed by Boeing, STELLA provides a generic software toolkit for Payload Developers to accommodate all of the unique software formatting required to communicate with the ISS.**
- **STELLA easily adapts Ethernet-based (TCP/UDP) software used in ground laboratories to software for conducting research on ISS; it enables a command and telemetry environment from ISS that is analogous to a terrestrial laboratory's control and data acquisition environment.**
- **STELLA functionality highlights:**
  - Payload commanding and payload file uplink
  - Remote console access to flight payload computer
  - Payload telemetry downlink and file downlink via the ISS Ethernet LAN
  - Payload health and status data routing to the Payload Operations Integration Center
- **Boeing assists Payload Developers with STELLA software integration as a standard ISS integration service**



Payload Testing for EXPRESS Rack

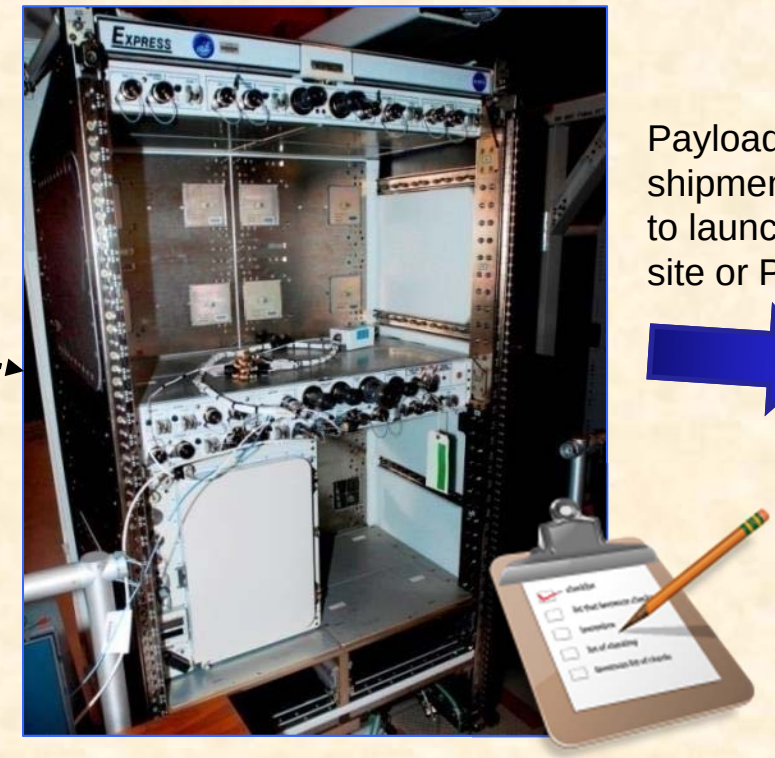
Payload

Rack simulator s/w provided for development

C&DH remote test possible using VPN

Virtual Private Network

EXPRESS Rack Functional Checkout Unit (MSFC)



Payload shipment to launch site or PD

Payload shipment to MSFC

Off-gas

Vibration

EMI/EMC

Acoustics

Additional Services Available

- Payload to rack interfaces verified efficiently for both Payload Developer and ISS
- End-to-end data flow from payload to rack to HOSC to PD ground station.
- Human Factors Team evaluates hardware locally
- Payload operations flight controller familiarization
- Validation of crew procedures

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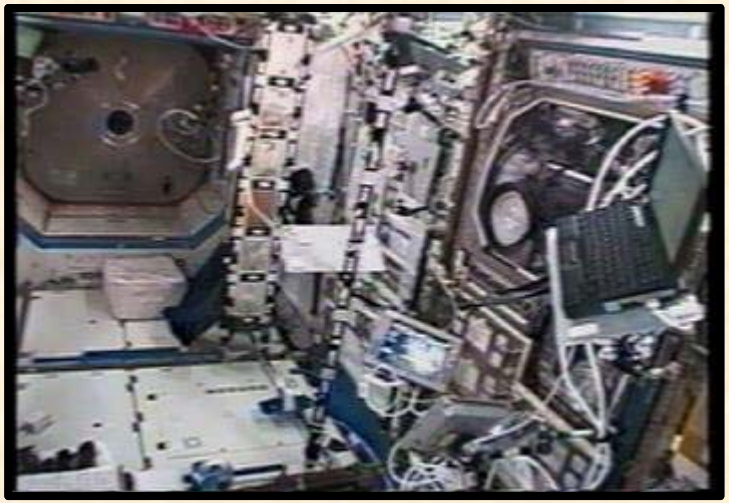
Microgravity Science Glovebox (MSG)

- The Microgravity Science Glovebox (MSG) is a payload rack facility designed for microgravity investigation handling aboard the International Space Station (ISS).
- The unique design of the facility allows it to accommodate science and technology investigations in a “workbench” type environment



- MSG facility provides an enclosed working area for investigation manipulation and observation in the ISS. Provides two levels of containment via physical barrier, negative pressure, and air filtration .
- The MSG facility is ideally suited to provide quick, relatively inexpensive access to space for Physical Science, Life Science, and Biological Science Investigations.

WORF Objectives/Description

Project Objectives

- The Window Observational Research Facility (WORF) Rack is a unique facility designed for use with the US Lab Destiny Module window.
- WORF provides valuable resources for Earth Science payloads along with serving the purpose of protecting the lab window.
  - The facility is used for remote sensing instrumentation test and validation in a shirt sleeve environment.
  - WORF payloads will be able to conduct terrestrial studies utilizing the data collected from utilizing WORF and the lab window.

Description

- Launched in April 2010 on 19A
- Rack Facility using standard ISPR and EXPRESS heritage hardware
- Provides Power and Data interfaces for up to 5 payloads
- Provides avionics air cooling for instruments and crew comfort; Moderate Temperature Loop Water cooling for avionics
- Provides stable mounting platform and “darkroom” environment for payload instruments

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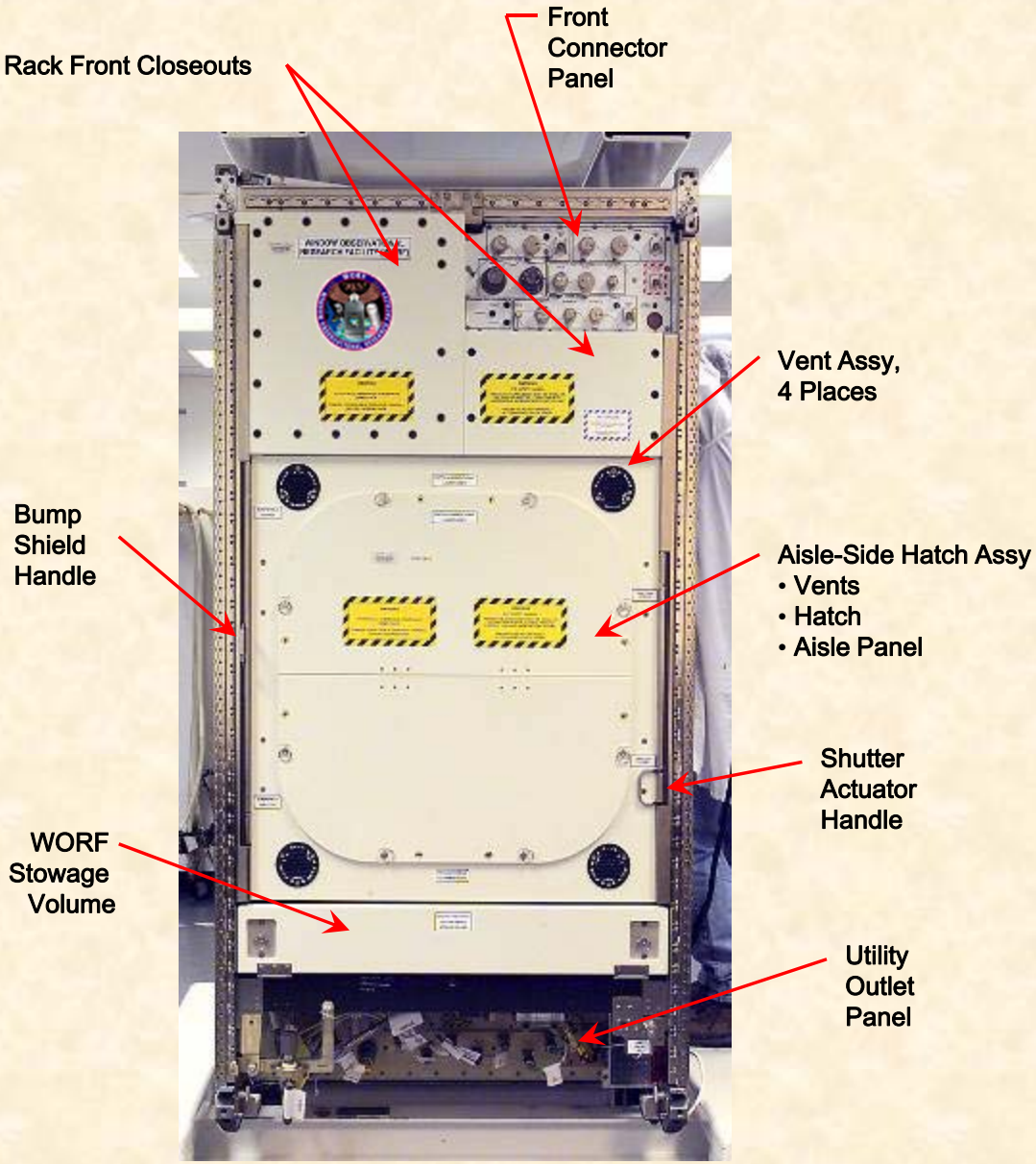
WORF Front View



The WORF Rack front face consists of the following:

- **Front connector panel**
- **Aisle side hatch**
- **Hatch vent assemblies**
- **Shutter Actuator Handle**
- **Bump Shield Handle**
- **Stowage Volume**
- **Utility Outlet Panel (UOP) connection**

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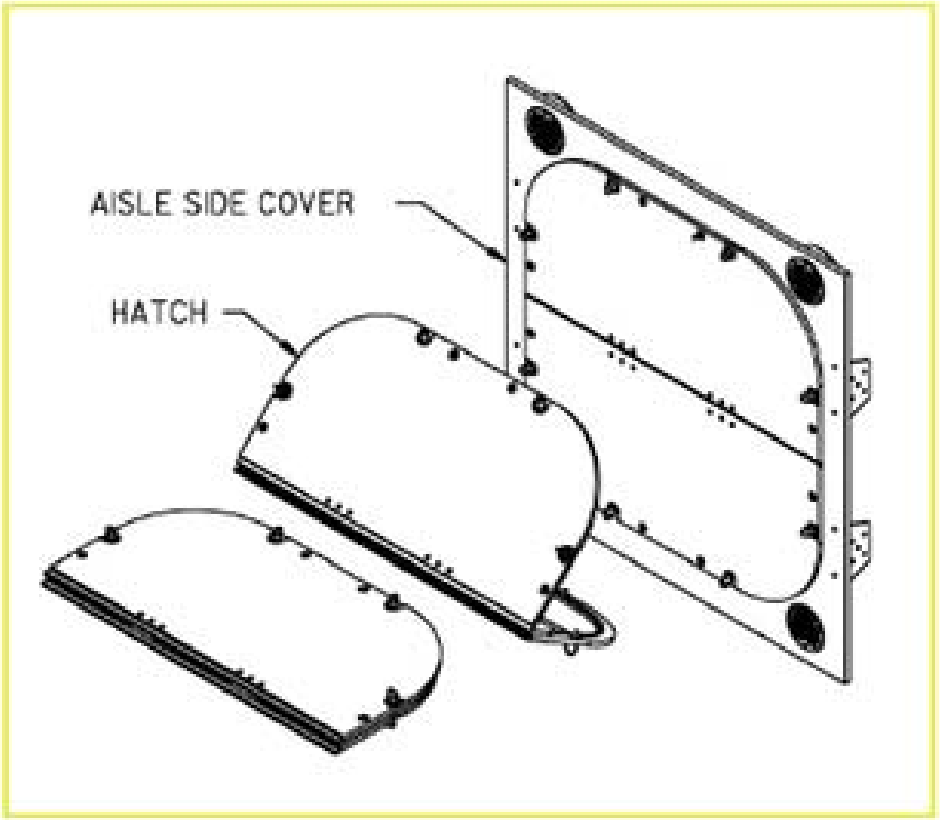
WORF – Aisle Hatch

- The WORF Aisle Hatch prevents unwanted light from entering the WORF Rack volume.
- Prevents loose items and debris from entering rack volume.
- Prevents installed payloads from being disturbed by passing crew members.
- Can be installed/removed very quickly without the use of tools. Designed to be stowed (folded) in the rack stowage drawer.



WORF

Project Objectives

- The **Window Observational Research Facility (WORF)** Rack is a unique facility designed for use with the US Lab Destiny Module window.
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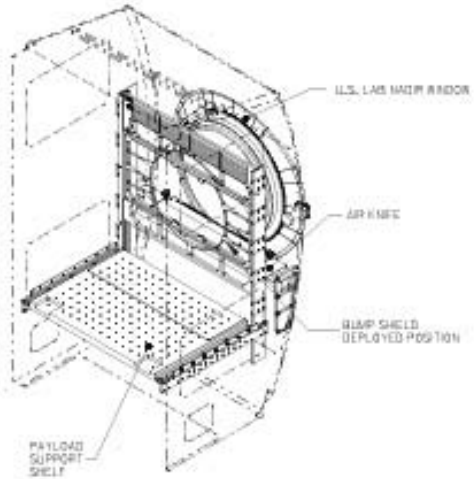
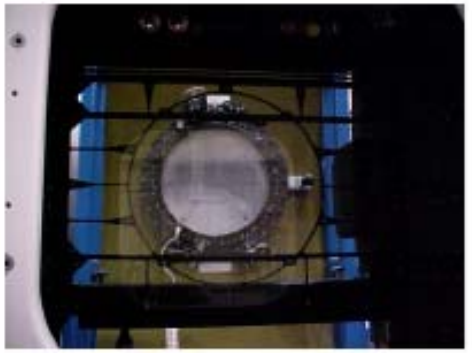
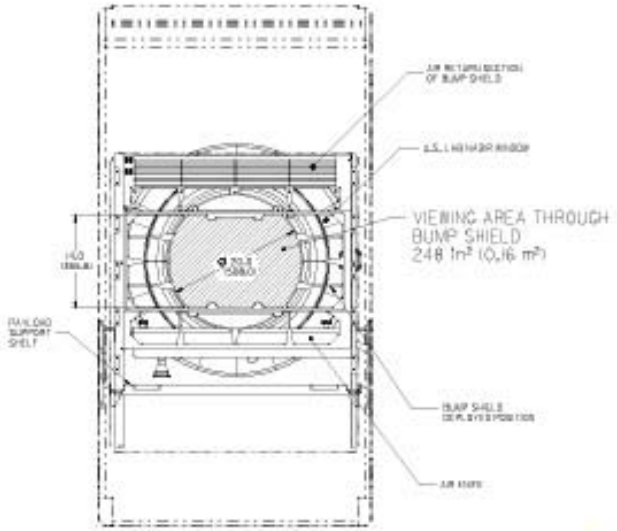
WORF – Bump Shield





- The Bump Shield provides protection to the US Lab window when crewmembers are working inside the payload volume
- It consists of three rectangular sections 9 inches, 14 inches, and 6 inches high, respectively
- Provides optical quality sufficient for low fidelity photographic operations.
- The bump shield can be retracted for higher quality imagery
- Made of Tuffak CM-2 (a transparent polycarbonate)

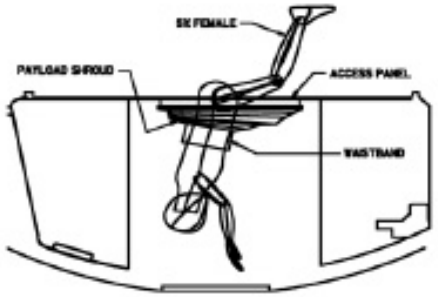


WORF FRONT VIEW
LOOKING THROUGH WINDOW

WORF- Soft goods

- WORF Payload Shroud available for hand-held imagery
  - Kayak skirt that seals out ambient light with a crewmember in the rack
- WORF stowage bags available to be used in payload volume
- Stow payload hardware; lenses, film, etc
- WORF Light Curtain is installed on front face to provide more light blockage

WORF Light Curtain



Crew Member Wearing Payload Shroud

Payload Shroud Installed

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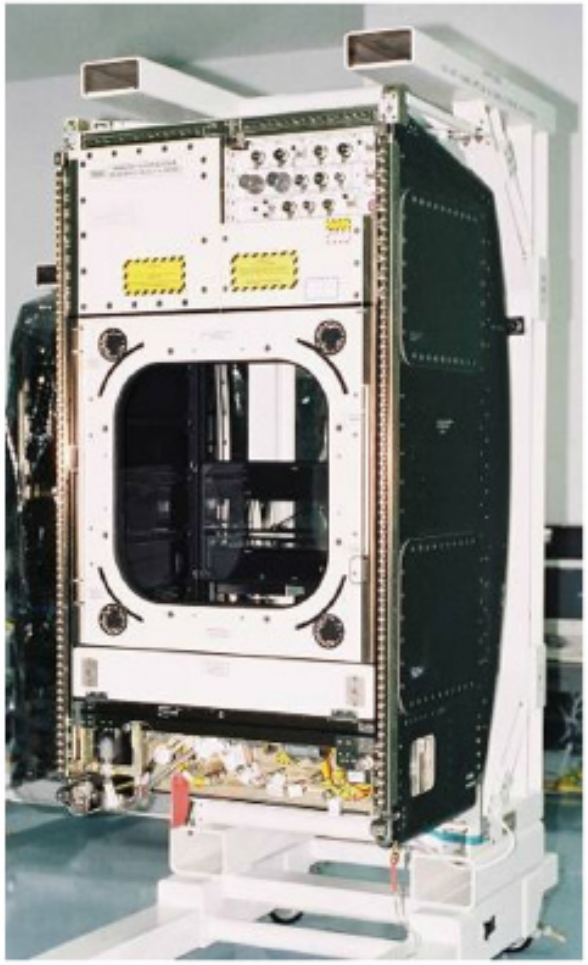
WORF - Resources

Power	• Solid State Power Controller Module (SSPCM) converts station power for payload use • 28Vdc Power (+1.5, -2.5 Vdc) provided to payloads • Current limiting available at 5, 10, 15, 20 amp settings • 1900 W possible but total is restricted by thermal constraints and overall vehicle capability • 120 Vdc interface in rack not for nominal payload use (can be negotiated)
Thermal	• Avionics Air Assembly (AAA) ducted cooling (50 cfm) provides 336 W heat rejection from the payload volume. An air knife provides air flow across the window to prevent condensation • Moderate Temp Loop (MTL) water cooling (40 lbm/hr) is available for 500 W heat rejection using the connections either on the rack front or internal connector panels. • Passive heat rejection to the cabin air is limited and allocated based on actual payload compliment. • Smoke detection available for air-cooled payloads
Data	• Each data connector includes pins for RS-422, Ethernet, NTSC RS-170A Video, 5 Vdc bi-directional differential discrete, +/- 5Vdc differential analog • Pass-through connectors include SCSI-2, S-Video, Ethernet, RS-232, RS-422 • WORF Laptop Computer available for payload-specific software and/or crew interfaces • Parameter monitoring available for water-cooled payloads

Not Available: Vacuum Resource, Vacuum Exhaust, Nitrogen, Low Temperature Loop

WORF – Specific Considerations

- The Lab Window Scratch Pane can be removed for higher quality optical requirements.
- WORF Payloads should design their hardware to minimize glare or ambient light reflections
- WORF payloads should be designed to be installed with the bump shield deployed to prevent contact with the Lab Window.
- Payloads should maintain a 0.5 in keep-out zone around the window assembly
- Payload lenses should incorporate bumper rings to prevent damage to the Lab Window in case of inadvertent contact
- There are a number of flight rules that govern window use during certain events.
- Crewmembers are restricted to 30 minutes of operation in the payload volume without the rack powered due to concerns of CO_2 concentrations.



MSG Facility Hardware Overview

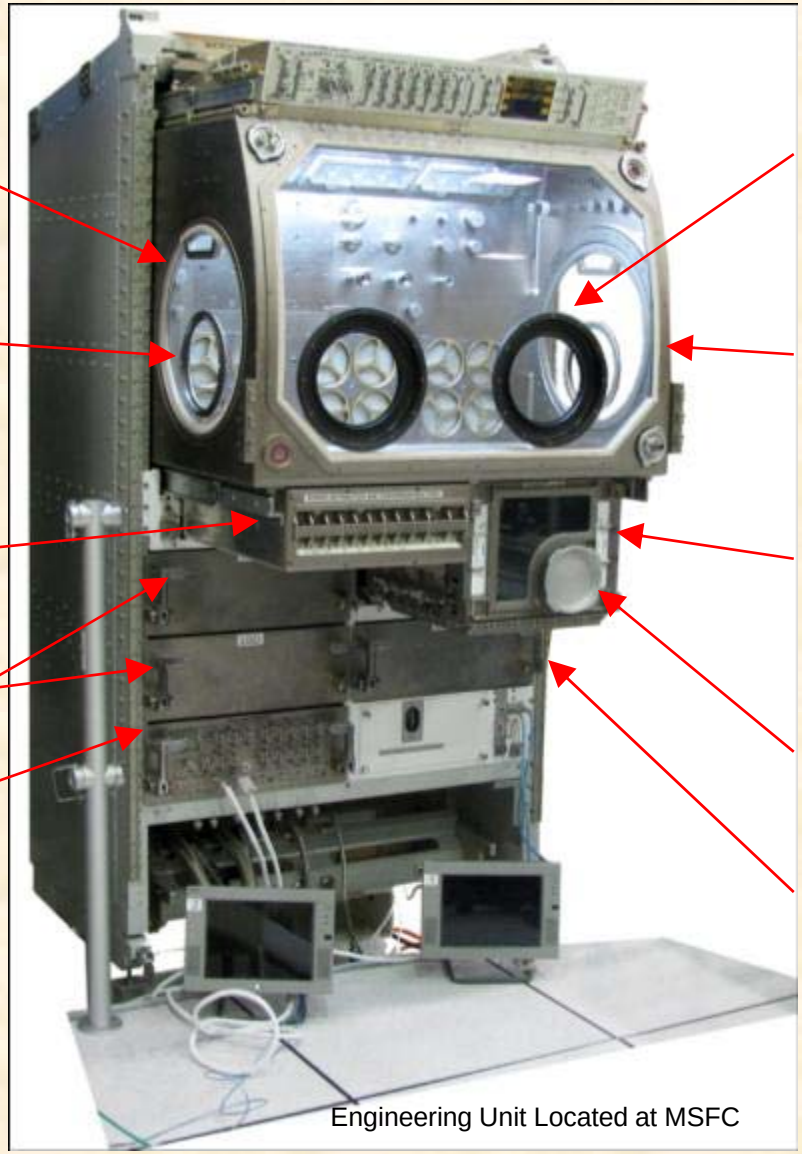
Removable Side Ports
16” diameter on both Left and Right sides for setting up hardware in Work Volume

Glove Ports
Four identical glove ports are located on the left and right side loading ports and the front window

DC Power Switching And Circuit Breakers

Stowage Drawers

Video System Drawer



Engineering Unit Located at MSFC

Front Window Glove Ports
Four 6” diameter glove ports can be fitted with any of three different sized gloves or blanks

Core Facility
Retractable Core Facility includes the Work Volume, Airlock, Power Distribution & Switching Box, and the Command and Monitoring Panel

Airlock
Provides a “Pass Through” for hardware to enter the Work Volume without breaking Containment. The lid of the Air Lock opens up into the floor of the Work Volume

Airlock Glove Port with Blank
A Single 4” diameter glove port can also be fitted with any of three different sized gloves or a blank

Stowage Drawers

Current MSG-Provided Payload Interfaces/Resources

- Work Volume(WV) - Volume
  - 0.255 m^3 = 255 liters
- Work Volume - Dimensions
  - 906mm wide x 637mm high
  - 500mm deep (at the floor)
  - 385mm deep (at the top)
- Maximum size of single piece of equipment in WV (via side access ports)
  - 406mm diameter
- Payload Attachment
  - M6 threaded fasteners in floor, ceiling, & sides
- Power available to investigation
  - +28V DC at useable 7 amps
  - +12V DC at useable 2 amps
  - -12V DC at useable 2 amps
  - +5V DC at useable 4 amps
  - +120V DC at useable 8.3 amps
- Maximum heat dissipation
  - 1000W Total
    - 800W from coldplate
    - 200W from air flow
- General illumination
  - 1000 lux @ 200mm above WV floor
- Video
  - 4 color Hitachi HV-C20 cameras
  - 2 Sony DSRV10 Digital Recorders
  - 2 Sony GV-A500 Analog 8mm Recorders
- Data handling connections
  - Two RS422-to-MSG for investigations
  - One MIL-BUS-1553B-to-MSG for communication via MLC
  - Ethernet LAN 1 and LAN 2 (in US LAB)
  - MSG Laptop Computer (MLC) – IBM T61P
- Filtration
  - 12 HEPA/charcoal/catalyst WV filters
- 1 HEPA/charcoal/catalyst Airlock filter
- Up to Two Levels of Containment
  - Physical barrier of MSG structures, gloves, etc.
  - Negative pressure generated by MSG fans.
- Other resources available
  - Gaseous Nitrogen
  - Vacuum (VRS & VES)

MSG Investigations

Payload Name & Acronym	Sponsoring Organization	Type of Investigation
Combustion Synthesis under Microgravity Conditions (COSMIC)	ESA	Combustion
Microgravity Experiment for the Measurement of Diffusion Coefficients in Crude Oil (DCCO)	ESA	Diffusion
NANOSLAB	ESA	Zeolite Crystal Growth
Protein Microscope for the International Space Station (PromISS-1,2,3, & 4)	ESA	Protein Crystal Growth
ARGES	ESA	Light Bulb Technology
HEAT	ESA	Heat Pipe Technology
Selectable Optical Diagnostics Instrument (SODI)	ESA	Diffusion and Soret Phenomena
Cell Wall/Resist Wall (CWRW)	JAXA	Plant Growth
Coarsening in Solid Liquid Mixtures-2 (CSLM-2)	NASA	Material Science
Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions (InSPACE-1,2, & 3)	NASA	Magnetorheological (MR) Fluids
IntraVenous Fluids GENeration and mixing (IV-Gen)	NASA	Human Health
Smoke Aerosol Measurement Experiment (SAME)	NASA	Spacecraft Smoke Detection
Shear History Extensional Rheology Experiment (SHERE)	NASA	Polymer
Smoke Point Coflow Experiment (SPICE)	NASA	Combustion
Critical Velocities in Open Capillary Channels (CCF)	NASA	Fluids
Structure and Liftoff in Combustion Experiment (SLICE)	NASA	Combustion
Burning and Suppression of Solids (BASS)	NASA	Combustion
Boiling eXperiment Facility (BXF)	NASA	Heat Transfer
Pore Formation and Mobility Investigation (PFMI)	NASA	Material Science
Solidification Using a Baffle in Sealed Ampoules (SUBSA)	NASA	Material Science
Rodent Research	NASA	Life Science
3D Printer	NASA	Technology Demonstration
Bioculture Systems	NASA	Life Science
Observation and Analysis of Smectic Islands in Space (OASIS)	NASA	Material Science
Zero Boil-Off Tank (Z-BOT)	NASA	Heat Transfer
Packed Bed Reactor Experiment (PBRE)	NASA	Physical Science
Transparent Alloys	ESA	Material Science

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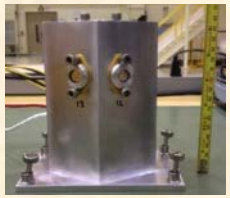
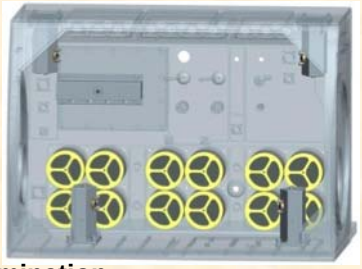
MSG LSAH Upgrades

- Materials utilized by Life Science/Biological Research payloads will require additional capabilities for handling and clean up:
  - Filtration System: a capability added to the existing MSG Work Volume air circulation system that scrubs typical life science biological and chemical contaminants from the MSG Work Volume air.
  - Decontamination System: a capability to reduce released biological contaminants (Bio Safety Levels (BSL) 1 and 2) to levels safe for crew exposure and a capability to remove released contaminants from surfaces within the Work Volume.
  - Exchangeable Glove System this is more suited for various life science activities.

Glove & Gauntlet Configuration

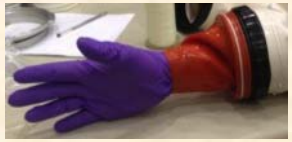
MSG Life Science Filters





Decontamination System

Iris & Gauntlet w/Disposable Glove



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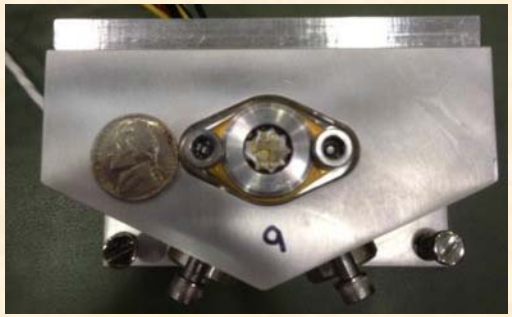
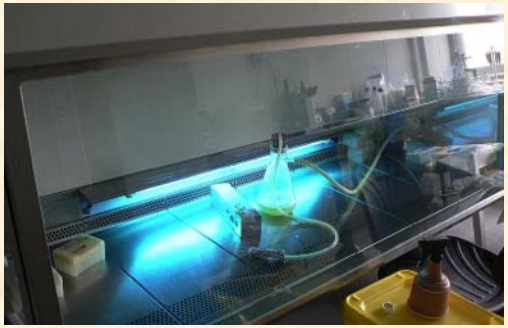
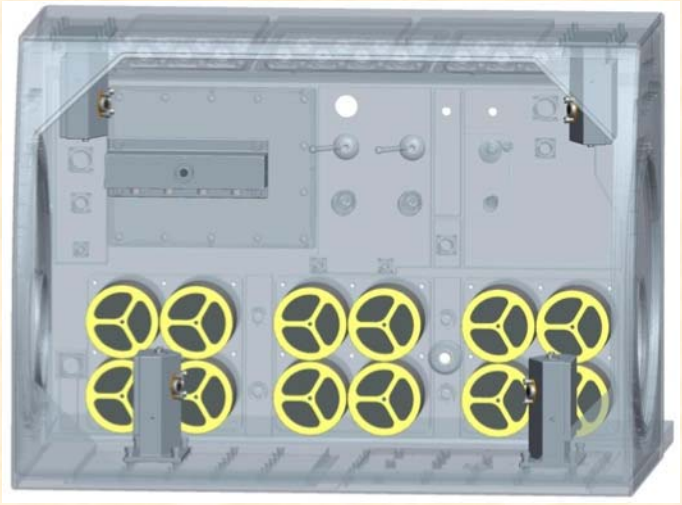
Decontamination System

- New Decontamination Capability within MSG Work Volume
  - Decontaminate before experiment to prevent contamination of biological samples
  - Decontaminate after experiment to disinfect any released biological materials
- Ground-based labs typically use UV Light or Ozone

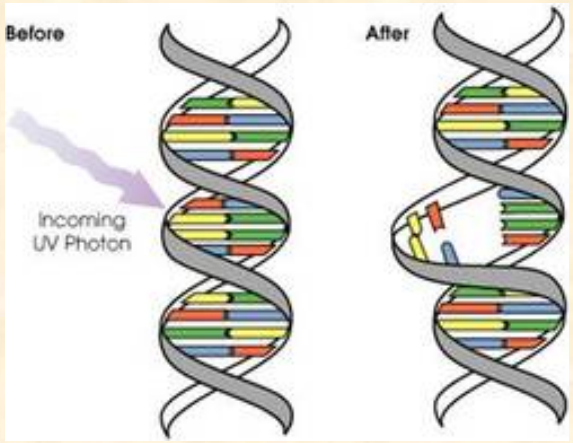




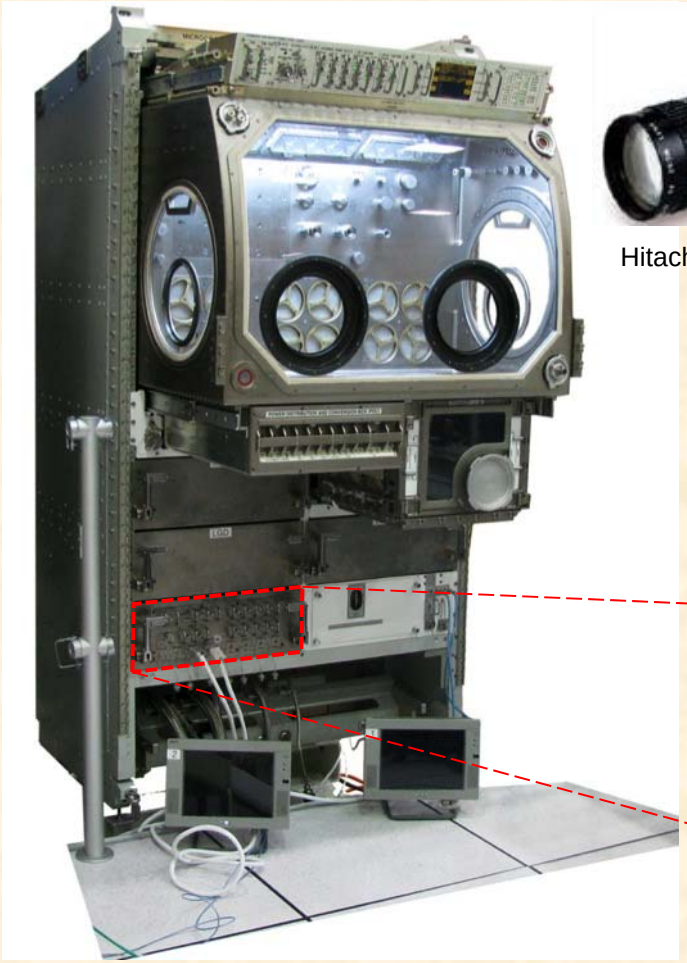


MSG Decontamination System

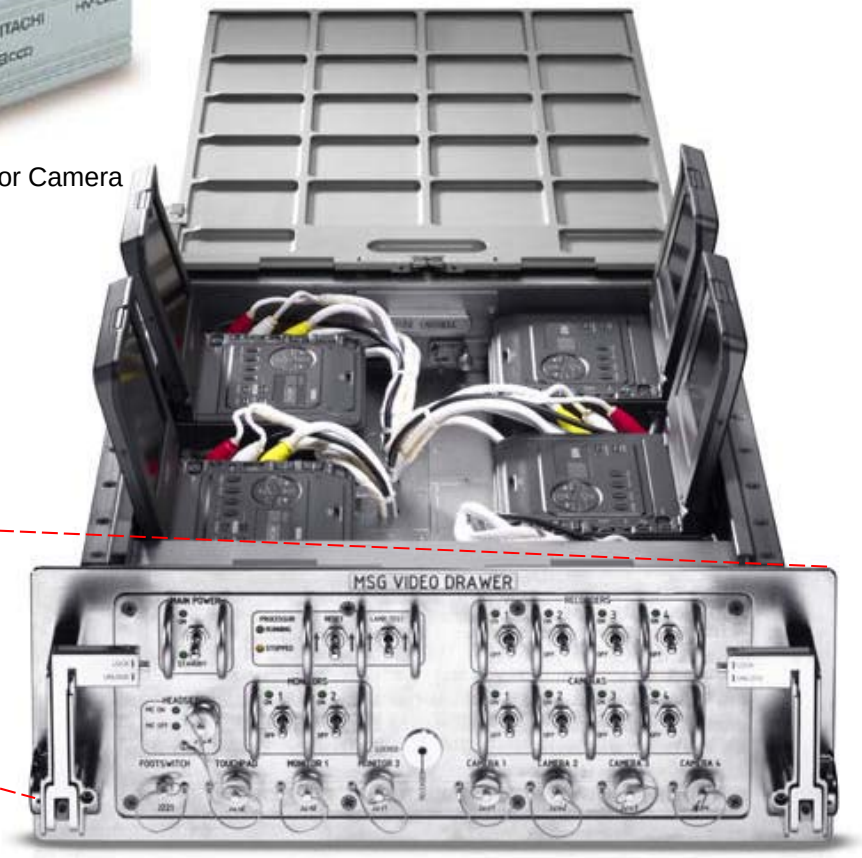
Ultraviolet germicidal irradiation is a sterilization method that uses ultraviolet light at sufficiently short wavelength to break down microorganisms. It is used in a variety of applications, such as food, air and water purification.



Current MSG Video System



Hitachi HV-C20 Color Camera



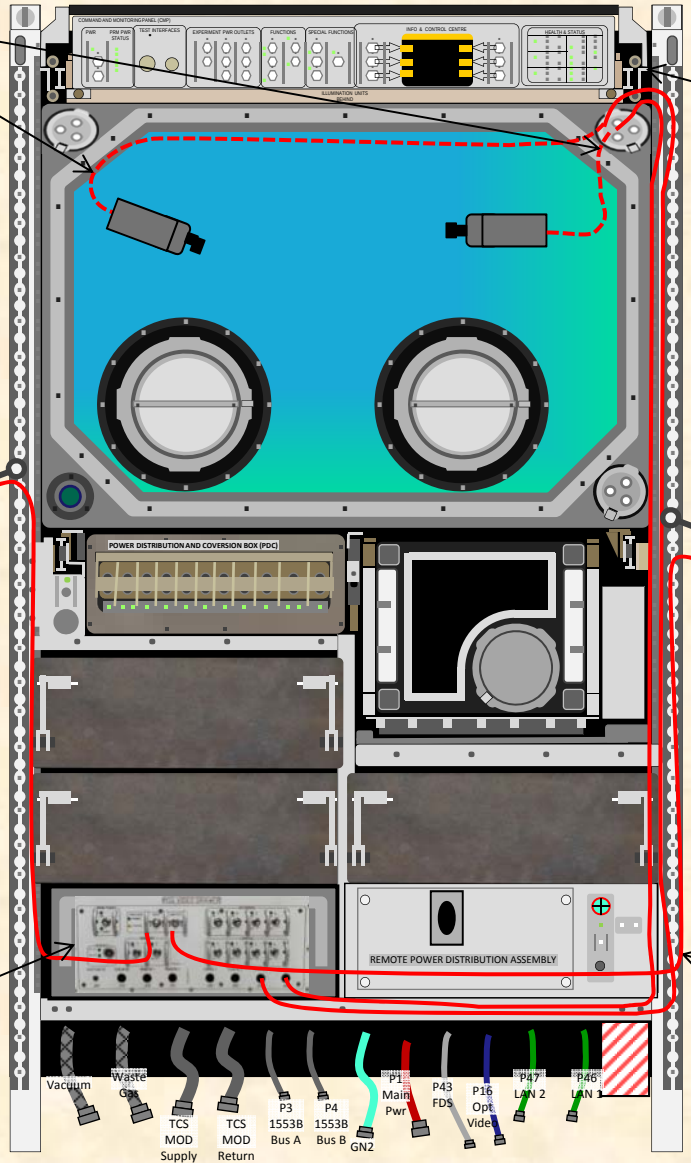
Pictured above in the bottom left drawer location of the MSG Engineering Unit, the MSG Video Drawer is shown connected to two video monitors. The Video Drawer is the main component of the MSG Video System.

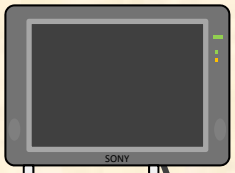
In additional to accommodating 4 exchangeable video recorders, the Video Drawer contains power, communications, and remote control systems. The front panel allows for the crew to switch power to individual cameras, recorders, and monitors and to connect the various external components, including cameras and monitors.

Typical MSG Video System Setup

The Video Drawer supports up to four cameras which can be located inside or outside the Work Volume. This example shows two cameras inside the Work Volume connected to the interior connectors of the video feed-thru.

Video Feed-thru's can be installed in any or all of the three feed-thru ports located on the upper-left, upper-right, and lower right of the Work Volume.





Two Video Monitors connect to the front panel of the Video Drawer. They could be located inside the Work Volume if required.

The Video Touchpad can be connected to either monitor or to the front Panel of the Video Drawer. It allows the crew to command the Video Drawer with a GUI display on the monitor.

The Video Drawer contains the video recorders, switcher, converters, and commanding system. Commands can be initiated from crew via the touchpad, from the ground, or from the experiment hardware.

W301 Video Extension Cables camera inside the work volume to the front panel of the Video Drawer via the video feed-thru.

Video System Overview

•The MSG Video Upgrade Equipment (VUE) will be capable of recording, storing, and transferring high definition/high resolution/high speed, color digital video data to ISS for downlinking.

• The VUE will utilize significantly higher video resolution and speeds than the existing MSG video system thereby enhancing research observation activities

- The MSG VUE consist of the following enhancements:
  - Powered ISIS drawer containing computer control and supporting electronics
  - High speed/high resolution cameras
  - High definition video cameras
  - GigE compatibility
  - Six terabytes of data storage via two 2 Tb Solid State RAID drives and two 1 Tb conventional hard drives.
  - Digital video data output capabilities for ISS to ground downlink. Downlink rates - up to 6 Mbps or higher depending on available bandwidth of the ISS LAN.


NASA

Summary

- These facilities on board ISS have been used for a large body of research in material science, heat transfer, crystal growth, life science, smoke detection and combustion research, plant growth, human health, and technology demonstration
- Process improvements and enhancements continue to improve the accommodations and make the integration and operations process more efficient.
- MSG and EXPRESS are ideal platforms for gravity-dependent phenomena related research. Moreover, ISS provides engineers and scientists a platform for research in an environment similar to the one that spacecraft and crew members will actually experience during space travel and exploration.
- The successful on-orbit operations and versatility of the EXPRESS Racks and MSG has facilitated the operations of many scientific areas, with the promise of continued payload support for years to come.

BACK UP